"THIRD CLASS. — MORAL AND POLITICAL SCIENCES.

First Division.	Moral and Intellectual Philosophy.
Second Division.	Philology and Ethnology.
Third Division.	Politics, Political Economy, and Jurisprudence.
Fourth Division.	Æsthetics."

"*Voted*, That the Secretaries be authorized and directed to cause to be prepared a suitable diploma or form of notification of election for the Foreign Honorary Members."

Dr. B. A. Gould, Jr. presented to the Academy, in behalf of its author, a volume entitled "The Exposition of 1851, or Views of the Industry, Science, and Government of England, by Charles Babbage, Esq.," and called attention to a new and uniform system of lighthouse signals, recommended by Mr. Babbage for universal adoption.

Three hundred and fifty-fifth meeting.

January 6th, 1852, — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Peirce, in behalf of the committee to whom was referred Lieutenant C. H. Davis's paper on the subject of the deterioration of Boston harbor, read the following report: —

"The committee to whom was referred the memoir of Lieutenant C. H. Davis upon the state of Boston harbor, have examined the same, and ask leave respectfully to report, that the memoir contains an enumeration of several changes that appear, by a comparison of the charts made at various times, and by other evidence, to have taken place in some of the most important channels of the upper harbor. This part of the memoir embraces a subject entirely local in its character; yet its importance, as affecting the prosperity of a great maritime city, our birthplace and home, may well compensate for the absence of that general interest which belongs to many other subjects of our transactions. The memoir, furthermore, contains an examination of the various causes by which the changes of the harbor have been brought about, influenced, or modified, and by which further changes may be produced. These causes are intimately connected with those general hydraulic forces which are at work wherever tides and streams

are known upon the earth's surface, and have thus a character as general as most subjects of geology or physical geography. The examination of these hydraulic forces, constantly at work in all tidal harbors, has led the author of the memoir to a general specification of the principles which ought always to govern constructions for the improvement of such harbors; and many rules are laid down, the understanding of which must be useful to the hydraulic engineer.

"The committee trust that this short summary of the contents of the memoir will enable the Academy to make a proper disposition of it. They abstain from expressing any opinion upon the accuracy or completeness of the memoir, as they hold to the wisdom of the rule, that the Academy will not, by itself or its committee, become responsible for the accuracy of any facts or opinions expressed by the authors of any memoirs.

"The committee recommend that the memoir of Lieutenant Davis be referred to the Committee on Publications. All of which is respectfully submitted.

"DANIEL TREADWELL,
BENJAMIN PEIRCE,
JOSEPH LOVERING,
HENRY L. EUSTIS,
MORRILL WYMAN.

"*Boston, January 6th*, 1852."

Voted, to refer the paper to the Committee on Publications.

The discussion of the subject of Mr. Guyot's communication at the last monthly meeting was continued by Professor Peirce, Dr. W. F. Channing, Mr. J. H. Abbot, Professor Lovering, Professor Eustis, Dr. B. A. Gould, Jr., Professor Horsford, and Dr. Jacob Bigelow.

Professor Peirce expressed his dissent from the opinion advanced by Professor Guyot, in respect to the amount of elevating force possessed by any whirlwind, which could be generated by the conflict of opposite winds. He computed the amount of this force in the case of a rotating body of air, extending the full height of the atmosphere, and demonstrated that it was insufficient to account for the phenomena to be explained. He also computed the elevating force possessed

by a column of air extending to the upper regions of the atmosphere, the temperature of which he supposed to have been raised, according to the principles of Espy's theory, forty degrees Fahrenheit, by the condensation of the aqueous vapor previously contained in it; and he inferred the existence, in this case, of a force capable of elevating bodies of considerable weight.

He stated that he had not been able to test the electrical theories by a similar process of computation, for want of sufficiently definite ideas of their nature. He thought, however, that indications of electrical action in tornadoes were so strong, as to make it very desirable that electricians should investigate the data requisite for such a computation.

Dr. W. F. Channing was satisfied that the causes usually assigned were insufficient to account for the mechanical effects of tornadoes, and was glad that a calculation of the forces of various theories had been undertaken by Professor Peirce. "The rotation in these storms is insufficient to produce a vacuum in the axis of the whirl, adequate to the elevation of heavy bodies by the means of the in-rushing and ascending air. In a water-spout which he had observed on Narraganset Bay, in 1845, the rotation of the trunk was obviously too slow to account for the elevation of the water which took place in the axis. An observer at Somerville had distinctly seen the rotation of the column of the tornado at West Cambridge, a mile and a half or two miles distant. When the smallness of the diameter of this revolving column (a few hundred feet) was considered, the velocity of rotation was at once reduced to a rate insufficient to account for the mechanical effects produced.

"In the beautiful experiment exhibited by Professor Guyot at the last meeting of the Academy, there was a permanent cause of rotation in the upper strata of the revolving fluid; that fluid was inelastic, and it was confined within the walls of a cylinder, which prevented the dispersive effect of the centrifugal force. In the case of the tornado, there is no

known intense and persistent cause of rotation at a given point in the upper atmosphere, and the effect of that rotation could hardly be propagated downwards through an elastic fluid by a narrow trunk, and without an adequate resisting agency to the centrifugal force. From both observation and theory, Dr. Channing was therefore disposed to regard the rotation as incidental to these phenomena, rather than their primary cause.

"It was necessary to have an axial cause which should continue to operate during the existence of the tornado, and confine these energetic phenomena within the limits of the trunk where the most powerful action takes place. The effect of rotation was to produce dispersion rather than this intense axial action so peculiarly restricted.

"Tornadoes are described usually as preceded or followed by electric phenomena, but rarely as accompanied at the same time with active electrical discharges. In the tornado, however, which crossed Providence River, in 1838, the trunk was seen to descend from the cloud, and the water to be agitated and raised beneath it. Successive flashes of electricity then passed through the trunk, apparently from the water to the cloud above. After each discharge, the agitation of the water appeared immediately to subside for a moment. Here was the common phenomenon of the spark drawn from the prime conductor, and the falling of the pith balls. The disturbance and elevation of the water under the point of the descending trunk, long before the completion of the column or any visible mechanical connection exists, is a fact of common observation in water-spouts. There is, therefore, reason from observation to infer a silent discharge of electricity by means of these trunks during a tornado. Such a discharge is, indeed, always a necessity of the case, the trunk of the tornado serving as a partial conductor between the clouds and earth. The tornado seems to exist, as a general rule, precisely when the moisture of the air or some other cause determines a silent discharge of electricity, instead of a discharge in the common form of the flash.

"When a trunk reaches down from a cloud, electrically excited, the discharge of electricity must resemble in character that from a point. With our small machines, the electricity, escaping from a pointed rod attached to the prime conductor, electrifies the air, and produces a blast sufficient to turn a small wheel. Yet Faraday estimates that several hundred thousand, or even million, turns of such a machine, are required to give the amount of electricity contained in a single flash of lightning; and the clouds from which the trunk of the tornado descends may perhaps furnish many hundred such flashes. On the scale of nature, therefore, this may become an intense axial force, producing powerful currents of air and other convective effects. If a silent electrical discharge between a great mass of clouds and the earth should be excited at a given point, the formation and descent of the trunk would almost necessarily follow, and a cause of permanent axial action would be established.

"The clouds, also, are huge floats, having a certain buoyancy, and liable to be drawn down towards the earth by electrical attraction. They must exert an equal reaction upon bodies on the surface of the earth. With our small machines, light bodies are raised in opposition to gravity, by an excited body held at some distance above them. On the immense scale of nature, this may also become a powerful cause antagonistic to the gravity of bodies, especially near the axis of convective discharge, where the inductive power of great masses of clouds is concentrated.

"These electrical causes are not presented as a theory of the tornado, to the exclusion of other active forces. They are, however, primary in their character, and based on familiar facts and analogies. They should therefore be subjected to mathematical calculation before they are set aside as insufficient to produce powerful mechanical effects."

Mr. J. H. Abbot, in addition to the theoretical objections which had been urged against the whirlwind theory, stated several observed facts, and referred to various forms assumed

by the tornado cloud as figured in Peltier's work, "Sur la Formation des Trombes," which he considered as utterly irreconcilable with that theory. He objected to the electrical theories of tornadoes as unsatisfactory, inasmuch as they refer the elevating force to the *attraction* between the cloud and subjacent bodies on the earth's surface. "The cloud with its cone is not a fixed, coherent mass, but is composed of free, disconnected, and mutually repellent parts, which are situated at unequal distances from the earth, and are therefore unequally attracted by its oppositely electrified surface; so that the only obstacle to the descent of the lower parts, in obedience to the electrical attractions, is their inferior specific gravity, compared with that of the underlying air. Any attraction, therefore, exerted by the cloud, sufficient to raise into the air men, wagons, and other heavy bodies, must necessarily, it should seem, cause the lowest and most strongly attracted portions of the cloud to rush with immense velocity to the earth, to be followed by others in their turn; a phenomenon which has never been observed."

The principal elevating agency of electricity in tornadoes had, he thought, been entirely overlooked by those who had written on the subject. This agency consisted, as he conceived, in augmenting the mutual repulsion of the particles of air and water composing the cloud, and thereby expanding it, and diminishing its specific gravity to an indefinite extent. "Hence must result great elevating force. The contiguous portions of the underlying air being acted upon by powerful attraction from above, and superior pressure from beneath, must rush up into the cloud with great velocity, and be followed by other portions in their turn. As this effect accumulates and is greatest in the cone where the electrical repulsion and consequent rarefaction are the greatest, the ascending currents of air must constitute a force capable of raising very heavy bodies. The cold that will result from this great expansion may account for the hail that usually accompanies the tornado."

Professor Lovering observed, that the vast disproportion be-

tween the quantity of electricity occasionally collected in the atmosphere, and that which could be held by the conductor of the largest electrical machine, had not, certainly, been exaggerated in the remarks already made. "It should not be forgotten, however, that the conductor, no less than the cloud, might be raised by the feeblest electromotive power to its state of maximum electrical tension, and that this maximum was higher for the conductor than for the cloud, on account of the diminished density of the air at the place where the cloud existed. If, therefore, the electrical attraction between a cloud and the earth is great, it must be the result, not of the surpassing tension of atmospherical electricity, but of the large surface which this tension covers; and the extent of surface must be sufficient to overcompensate for the unusual distance through which the electrical forces act. Although it may be questioned whether the forces thus considered are adequate to produce the terrible mechanical movements which accompany the tornado, they are doubtless competent to draw down the cloud in the form of an inverted pyramid towards the earth's surface. Here the agency of the electrical tension may be supposed to terminate, and that of the quantity to begin to play its part; and as this quantity may be exceedingly great, the effects of its discharge from this cone of cloud pointing to the earth may, in the same proportion, surpass the feats of the electrician in his experiments with the machine of his own invention. In whatever way the motion of the air which is observed at the time of the brush discharge from the pointed conductor is explained, that motion, we may admit, will be multiplied into the force of a hurricane, if it corresponds with the great amount of electricity which has accumulated in the prime conductor of our planet. A reason for the fact that the electricity seeks its way to its resting-place in the solid earth by the *thunderbrush*, and not by the *thunderbolt*, may be found, in one instance at least, in the extraordinary aridity of the earth's surface, in consequence of which that surface could not receive and distribute the charge from one point, but each spot drank its own portion from the inverted cup as it was handed along."

Professor Eustis remarked, that he had carefully surveyed the track of the tornado, and had made a plan of it, in which he had laid down the prostrate trees and other important objects in their exact positions, as determined by an accurate survey. Having formed no theory upon the subject, he had made his observations without bias from that cause. He compared the general appearance of the track to that which would be produced by a heavy body of enormous size, moving forward with great momentum, so as to throw down every obstacle in its path. In one or two places only, the position of the prostrate trees indicated the action of a rotating force. In one place a tree was twisted 180° at the height of ten feet from the ground. Professor Eustis mentioned another fact, which he referred to the direct agency of electricity; namely, that a hole as large as a silver half-dollar, with its edge well defined and free from cracks, though slightly fused, had been made in a pane of glass in an inner window. A considerably smaller hole was found in the window curtain, opposite to the large hole in the glass.

Professor Horsford presented a paper, "On the Permeability of Metals to Mercury," in which, after remarking on the researches of Daniel and Henry, he gave an account of a series of original experiments, with a view to the elucidation of the laws of this phenomenon. The following is a summary, in his own language, of the results at which he arrived: —

1. The specific gravity of lead is increased by saturation with mercury.

2. The velocity of the mercury diminishes as the length of a saturated bar increases, and in a kind of geometrical ratio.

3. The progress is more rapid in cast than in drawn lead.

4. The total height to which the mercury attains is greater in cast than in drawn lead.

5. Gravity facilitates the flow of mercury from above downwards.

6. The mercury which passes through a siphon-shaped bar of lead contains lead in solution.

7. This lead is derived from the interior of the bar.

8. After the transmission of a certain amount of mercury, and the return of this mercury to be passed again, the amount transmitted in a given time attains a maximum.

9. The amount passed in a given time with a given length of the shorter leg of the siphon is dependent on the extent of absorbing surface exposed to the mercury.

10. The siphon action is limited by the same law that determines the height or length of bar through which mercury will pass.

11. Mercury saturated with lead passes through leaden bars.

12. The saturated bar is eminently brittle.

13. The saturated bar contains 3.55 per cent. of mercury, and 96.45 per cent. of lead.

14. The bar saturated with, and afterwards withdrawn from the mercury, lost in seven months, by atmospheric diffusion, 2.75 per cent. of mercury, leaving only .80 per cent. in the bar.

15. In this condition the bar had nearly recovered its original texture.

16. After the loss of a certain amount by diffusion, the surface becomes coated with crystallized amalgam, and the diffusion ceases.

17. The liquid amalgam contains 2.52 per cent.

18. The saturated bar, long in contact with mercury, assumes a crystalline texture, and cracks open.

19. After crystallization commences, the progress of the mercury is impeded.

20. The specific gravity of tin is increased by saturation with mercury.

21. The saturated bar soon opens by numerous fissures presenting crystalline angles and surfaces.

22. The specific gravity of the crystalline amalgam is greater than that of the bar nearly saturated with mercury.

23. The velocity of transmission of mercury through tin is at first slower than that through lead, but it differs in

being uniform, while the velocity in lead diminishes very rapidly.

24. The siphon action with a tin bar cannot be long maintained, on account of the crystallization and consequent brittleness of the bar.

25. The crystalline amalgam has a constitution of $Hg\ Sn_8$.

26. The liquid amalgam contained 1.55 per cent. to 1.73 per cent. of tin.

27. The crystalline amalgam loses nothing by atmospheric diffusion.

28. Quicksilver permeates gold and silver, but very slowly.

29. Zinc and cadmium are permeable to mercury, but dissolve in it.

30. Iron, platinum, palladium, and copper bars are not at common temperatures permeable to mercury.

Three hundred and fifty-sixth meeting.

January 28, 1852. — ADJOURNED STATUTE MEETING.

PROFESSOR PEIRCE in the chair.

The Recording Secretary reported a list of the Members of the Academy, arranged in classes and sections by the Council, agreeably to the vote of the Academy at its last statute meeting.

The Academy then proceeded to consider the amendments to the statutes reported by Professor Peirce at the last statute meeting. After some discussion, it was

Voted, That the amendments to the statutes, proposed at the adjourned statute meeting held December 3, 1851, be adopted.

Dr. B. A. Gould, Jr. stated several reasons, which he thought rendered it desirable that the nomination of Foreign and Associate Members should be vested, as far as practicable, in those sections of the Academy, to which, if elected, they would belong. After a long discussion, he offered the following amendment to the statutes: —